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IS 12677 (1989): Internal fuses for series capacitors [ETD 29: Power Capacitors]



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Indian Standard

**INTERNAL FUSES FOR SERIES
CAPACITORS — SPECIFICATION**

भारतीय मानक

श्रेणी संधारित्रों के लिये आन्तरिक फ्यूज — विशिष्ट

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FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards on 3 April 1989, after the draft finalized by the Power Capacitors Sectional Committee had been approved by the Electrotechnical Division Council.

It is intended to formulate uniform requirements regarding performance and testing of internal fuses for series capacitors. This standard also provides a guide for coordination of fuse protection to series capacitors covered in IS 9835 : 1981 'Specification for series capacitors for power systems'.

The fuses conforming to this standard are designed to isolate faulted capacitor elements to allow the operation of remaining parts of that capacitor unit and the bank in which the capacitor unit is connected. Such fuses are not a substitute for a switching device such as a circuit breaker, or the external protection of the capacitor bank, or part thereof. The design of internal fuse is specifically matched with that of the series capacitor.

This standard is based on the following publications/documents issued by the International Electrotechnical Commission (IEC):

- a) IEC Pub 595 (1977) and Amendment No. 1 (April 1980) Internal fuses for series capacitors; and
- b) Doc : 33(C.0)72 Draft Amendment No. 2 to IEC Pub 595 (1977).

Indian Standard

INTERNAL FUSES FOR SERIES CAPACITORS — SPECIFICATION

1 SCOPE

1.1 This standard covers the requirements, tests and guidance for coordination of fuses used to protect series capacitors in accordance with IS 9835 : 1981 'Specification for series capacitors for power systems'.

1.2 This standard does not apply to fuses for which the service conditions, in general, are incompatible with the requirements of the standard unless otherwise agreed between the manufacturer and the purchaser.

1.3 The guidance for coordination of fuse protection is given in Annex A.

2 REFERENCES

2.1 The following Indian Standards are necessary adjuncts to this standard:

IS No.	Title
IS 1885 (Part 42) : 1986	Electrotechnical vocabulary: Part 42 Power capacitors
IS 9224 (in parts)	Specification for low voltage fuses
IS 9226 : 1979	Recommendations for load distribution for passenger cars
IS 9385 (in parts)	Specification for high voltage fuses
IS 9835 : 1981	Specification for series capacitors for power system
IS 9926 : 1981	Specification for fuse wire used in rewirable type electric fuses up to 650 V

3 TERMINOLOGY

3.1 The following definitions in addition to those given in IS 1885 (Part 42) : 1986 shall apply.

NOTE — The word element in this standard is used in accordance with the definitions contained in IS 1885 (Part 42) : 1986, and not in accordance with IS 9224, IS 9226 : 1979 and IS 9385.

3.2 Internal Fuse

A fuse connected inside a capacitor unit in series with an element or group of elements.

3.3 Bank Protection

A general term for all protective equipment for a capacitor bank, or part thereof.

3.4 Unbalance Protection

A device sensitive to capacitance difference between branches of the bank normally in balance with each other. The capacitance difference may be due to a blown fuse(s), or insulation failure within the bank.

NOTE — Other protective devices, such as, overcurrent and earth fault protection, are self-explanatory since they are commonly used for other application.

4 GENERAL REQUIREMENTS

4.1 The fuse is connected in series to the element(s) which the fuse is intended to isolate if the element(s) becomes faulty. The range of currents and voltages for the use is, therefore, dependent on the capacitor design, and in some cases also on the bank in which the fuse is connected.

4.1.1 The operation of an internal fuse is, in general, determined by one or both of the following factors:

- a) The discharge energy from elements or units connected in parallel with the faulty element or unit; and
- b) The power frequency fault current.

5 DISCONNECTING REQUIREMENTS

5.1 The fuse shall enable the faulty element to be disconnected when electrical breakdown of elements occurs in a voltage range in which u_1 is the lowest, and u_2 the highest (instantaneous) value of the voltage between the terminals of the unit at the instant of fault.

5.2 The recommended values for u_1 and u_2 are the following:

$$u_1 = 0.5\sqrt{2}U_N$$

$$u_2 = \sqrt{2}U_{lim}$$

NOTES

1 The u_1 and u_2 values above are based on the voltage that may normally occur across the capacitor unit terminals at the instant of electrical breakdown of the element.

The u_2 values are of a transient nature.

The purchaser shall specify if the u_1 and u_2 values differ from the stated ones. If so, the value stated in 10.1 and 10.4 shall be changed accordingly.

2 The u_2 values cannot be exceeded due to the spark-gap. A lower voltage than the u_1 value can occur in service but breakdowns are unlikely to take place under these conditions.

6 WITHSTAND REQUIREMENTS

6.1 After operations, the fuse assembly must withstand full element voltage plus any unbalance voltage due to fuse action and any short-time transient overvoltage normally experienced during the life of the capacitor.

6.2 Throughout the life of the capacitor, the fuse shall be capable of continuously carrying a current equal to or greater than the maximum permissible unit current (*see* 5.1 of IS 9835 : 1981) divided by the number of parallel fused paths.

6.3 The fuse connected to the undamaged element(s) must be able to carry the discharge currents due to the breakdown of element(s).

6.4 The fuses must be able to carry the currents due to short-circuit faults external to the unit(s) on the occurring within the voltage range in accordance with 5.

7 MARKING

7.1 The marking regarding the presence of internal fuse in capacitor shall be provided on the rating plate of the series capacitor.

8 TESTS

8.1 Type Tests

The following shall constitute type tests:

- a) Discharge test (9), and
- b) Disconnecting test (10).

In addition, the fuses shall be able to withstand all type tests of the capacitor units in accordance with IS 9835 : 1981.

8.1.1 Type tests of fuses are performed either on one complete capacitor unit or, at the choice of the manufacturer, on two units, one unit being tested at the lower voltage limit, in accordance with 10.1 and one unit at the upper voltage limit. The unit(s) shall have passed all routine tests stated in IS 9835 : 1981.

NOTE — Due to testing, measuring and safety circumstances, it may be necessary to make modifications to the unit(s) under test; for example, those indicated in Annex B. The different test methods are also given in Annex B.

8.1.2 Type tests are considered valid if they are performed on capacitors of a design identical with that of the capacitor offered, or on a capacitor of a design that does not differ from it in any way that might affect the properties to be checked by the type tests.

8.2 Routine Tests

8.2.1 The fuses shall be able to withstand undamped discharge from a unit charged to a voltage of at least $1.7 U_N$ ($1.2 \times \sqrt{2} \times U_N$) (*see* IS 9835 : 1981).

9 DISCHARGE TEST

9.1 The fuses shall be subjected to the discharge test stated in IS 9835 : 1981.

NOTE — The partial discharge test of the above-mentioned standard does not apply.

9.2 To prove that the fuses have not operated, capacitance measurement shall be made before and after the test. A measuring method shall be used that is sufficiently sensitive to detect the capacitance change caused by one blown fuse.

10 DISCONNECTING TEST

10.1 Test Procedure

The disconnecting test on fuses is performed first at the lower ac test voltage of $0.5 U_N$ and then, as soon as possible after the blowing of one fuse at the upper ac test voltage of $1.1 U_{lim}$ until the blowing of another fuse.

10.1.1 Certain test methods are indicated in Annex B.

NOTE — If the test is carried out with dc, the test voltage shall be $\sqrt{2}$ times the corresponding ac test voltage.

10.2 Capacitance Measurement

After the test, capacitance shall be measured to prove that the fuse(s) has (have) blown.

10.2.1 A measuring method shall be used that is sufficiently sensitive to detect the capacitance change caused by one blown fuse.

10.3 Inspection of the Unit

Before opening, no significant deformation of the container shall be apparent.

10.3.1 After opening the container, a check should be made to ensure that:

- a) No significant deformation of sound fuses is apparent; and
- b) Not more than one additional fuse (or one-tenth off used elements directly in parallel) has been damaged (Annex B Note 1). If method (b) in Annex B is used, the note must be observed.

NOTE — A small amount of blackening of the impregnant will not affect the quality of the capacitor.

10.4 Voltage Test After Opening the Container

A dc test voltage equal to $1.7 U_{lim}$ shall be applied for 10 s across the broken down element and the gap in its blown fuse. During the test, the gap shall be in the impregnant.

No breakdown over the fuse gap is allowed.

NOTE — For unit with all elements in parallel and for all units if any of the test procedure (*see* B-3 to B-6) indicated in Annex B is used, this test can be replaced by an ac test before the opening of the unit. The test voltage between the terminals is selected through calculations using capacitance ratio such that the voltage across the breakdown element and the gap in its blown fuse is the above value divided by $\sqrt{2}$.

ANNEX A

(Clause 1.3)

GUIDE FOR CO-ORDINATION OF FUSE PROTECTION

A-1 GENERAL

A-1.1 The fuse is connected in series with the element that the fuse is designed to isolate if the element becomes faulty. After the breakdown of an element, the fuse connected to it will blow and isolate it from the remaining part of the capacitor, which allows the unit to continue in service.

A-1.2 The blowing of one or more fuses will cause voltage changes within the bank.

A-1.3 The voltage across sound unit(s) must not exceed the value given in the relevant standard.

A-1.4 Depending upon the internal connection of the units, the blowing of one or more fuses may also cause a change of voltage within the unit.

A-1.5 The remaining elements in a series group will have an increased working voltage and the manufacturer shall, on request, give details of the voltage rise caused by the blown fuses.

A-2 PROTECTION SEQUENCE

A-2.1 The protection of a capacitor bank must operate selectively.

A-2.1.1 The first step is the fusing of the element(s).

A-2.1.2 The second step in the relay protection of the bank (for example, overcurrent or unbalance protection).

A-2.1.3 The third step is network or plant protection.

NOTES

1 Depending on the output of the bank, the design of the relay protection, etc, all the three steps are not necessarily used in all capacitor banks.

2 In large banks, an alarm stage may also be used.

3 Unless the fuse always blows as a result of discharge energy within the voltage range in 6, the manufacturer shall provide the current/time characteristic and tolerances of the fuse.

ANNEX B

[Clauses 8.1.1 (Note) 10.1.1, 10.3.1(b) and 10.4 (Note)]

TEST PROCEDURE FOR THE DISCONNECTING TEST ON INTERNAL FUSES

B-1 GENERAL

B-1.1 One of the test procedures given in B-2, B-3, B-4, B-5 and B-6 or an alternative method, shall be used.

B-1.2 If no agreement has been reached, the choice is left to the manufacturer (see also Note to 8.1.1).

NOTES

1 At the upper voltage limit, an additional fuse (or one-tenth of the fused elements directly in parallel) connected to a sound element(s) is allowed to be damaged.

2 The test voltage shall be maintained some seconds after a breakdown to ensure that the fuse has disconnected correctly, unaided by disconnection of the power supply.

3 In special cases, it may be necessary to extend the tests until two or more breakdowns of capacitor elements have occurred. The number of breakdowns at each voltage limit shall, in such cases, be subject to agreement between the manufacturer and the purchaser. If the number of breakdowns is exceeded, the voltages stated in 10.4 may have to be increased.

4 To verify the current limiting behaviour of the fuses when tested at the upper voltage limit, the voltage drop, excluding transient, across the blown fuse must not exceed 30 percent.

5 If the fuse does not fulfil the requirements of Note 4, precautions must be taken to make certain that the parallel stored energy and the power-frequency fault current available from the system are representative of service conditions. A test shall then be made to demonstrate satisfactory operation of the fuse.

6 Precaution shall be taken when performing this test against the possible explosion of a capacitor unit and the explosive projection of the nail.

B-2 CAPACITOR PREHEATING

B-2.1 The capacitor unit is preheated in a chamber before applying the ac test voltage at the lower limit. Preheating temperature (100 to 150°C) is chosen by the manufacturer to achieve a practical short time (from few minutes to few hours) to the first breakdown.

B-2.2 A lower preheating temperature should be used when applying the test voltage at the higher voltage limit, to avoid breakdowns before reaching the test voltage.

B-2.3 Capacitor current is to be recorded during the test.

NOTE — To prevent excessive internal liquid pressure due to high temperature, the unit may be equipped with a relief tube including a valve which must be closed at the instant of applying the test voltage.

B-3 MECHANICAL PUNCTURE OF THE ELEMENT

B-3.1 Mechanical puncture of the element is made by a nail which is forced into the element through a pre-drilled hole in the container. The test voltage may be dc or ac, the choice being left to the manufacturer.

B-3.2 If ac voltage is used, capacitor current is to be recorded during the test and timing of puncture is to be made, to ascertain that the breakdown is triggered to take place at the instant of the peak of the ac test voltage, or very near to it.

NOTES

1 Puncture of only one element cannot be guaranteed.

2 In order to limit the possibility of a flashover to the container along the nail, or through the hole caused by the nail, the punctures may be performed to the elements connected, permanently or during the test, to the container.

3 dc voltage is especially suitable for capacitors having all elements in parallel.

B-4 ELECTRICAL BREAKDOWN OF THE ELEMENT (FIRST SOLUTION)

B-4.1 Some elements in the test unit are each provided with, for example, a tab, inserted between the dielectric layers. Each tab is connected to a separate terminal.

B-4.2 The test voltage may be ac or dc, the choice being left to the manufacturer.

B-4.3 To obtain breakdown of an element thus equipped, a surge voltage of sufficient amplitude is applied between the tab and one of the foils of the modified element.

B-4.4 In the case of ac voltage, the surge must be triggered at the instant of the peak or very near to it.

B-4.5 Capacitor current is to be recorded during the test.

B-5 ELECTRICAL BREAKDOWN OF THE ELEMENT (SECOND SOLUTION)

B-5.1 Some elements in the test unit are each provided with, for example, a short fuse connected to two extra tabs and inserted between the dielectric layers. Each tab is connected to its own bushing.

B-5.2 The test voltage may be dc or ac, the choice being left to the manufacturer.

B-5.3 To obtain breakdown of an element equipped with this short fuse wire, a capacitor charged at a sufficient voltage is connected to the two bushings connected to it in order to explode the wire.

B-5.4 In the case of ac voltage, the connection of the charged capacitor causing the wire explosion must be triggered at the instant of the peak voltage or very near to it.

B-5.5 Capacitor current is to be recorded during the test.

B-6 ELECTRICAL BREAKDOWN OF THE ELEMENT (THIRD SOLUTION)

B-6.1 A small part of an element (or some elements) in a unit is at the time of manufacture removed and replaced with a weaker dielectric.

For example, 10-20 cm² of a film — paper — film dielectric is punched away and the hole is covered with two thin papers.

B-6.2 This method will require experience on how to make a suitable dielectric strength reduction.

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